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TideNet: A Web-based Tidal Data Access, Processing and Analysis Tool, Part 1 – NWS Tidal Database

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PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes the second module of the MetOcnDat (Meteorological and Oceanographic or Metocean) system, called TideNet. The MetOcnDat modular system in development consists of toolboxes for waves, tides, and river flow databases that will facilitate conversion of data used in input files for numerical models and provide tabular and graphical information for project planning and design reports. TideNet is a web-based Graphical-User-Interface (GUI) data management tool that allows users to access, process, and analyze tide data available from different tidal databases. This first application of TideNet deals only with tide data from the National Weather Service (NWS) database used in various coastal, ocean, and marine engineering applications.

BACKGROUND: Metocean data include winds, waves, tides (water levels and currents), and river discharges. The first two Technical Notes (TNs) in the MetOcnDat system series (Demirbilek et al. 2013; Wilson et al. 2012) described the application of WaveNet, a companion module of TideNet, for the National Data Buoy Center (NDBC) buoy and Wave Information Study (WIS) databases. The TideNet is a web-based GUI that provides users with GIS mapping tools to query tide data sources in a desired geographic region of USA and its territories. Users can select a tide data source through the Google Map® interface to view data and parameters of interest. The utilities of TideNet available at the selected tide data source can query the data source, then plot, analyze, and extract tidal information based on a user-specified time window and output data in different formats for engineering applications. TideNet has additional post-processing capabilities to produce tables and figures and prepare input files for numerical models.

The TideNet toolbox can fetch tide data, including plots and tables from the source, or may be used to process the tide data downloaded from any source site to perform additional analyses. The display and plotting options include text (ASCII) files of tide record time series, histograms of data, and image files (.png) or portable document (.pdf) of plotted data. The numerical model support in TideNet allows users to select a model (e.g., CMS-Wave, CMS-Flow, STWAVE, etc.) for which to prepare input water level data.

After a brief description of tides and databases, general features of TideNet are illustrated with an application example in a step-by-step manner, with comments and instructions.

Tidal harmonic constituents (Hendershott 1981) represent changes in tides that are created by different frequencies of astronomical forcing, which arise due to the gravitational influences of the Moon and Sun on Earth, the tilt of the rotational axis of Earth, the elliptical shape of the Moon's orbit around Earth, the shape of Earth's orbit around the Sun, and other such factors (<http://tidesandcurrents.noaa.gov/about2.html>). Each constituent represents a periodic change or variation in the relative positions of Earth, Moon, and Sun and has a period of less than half a day.

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Many constituents have been defined and are classified based on their cycle lengths. Most of the tidal constituents used are either diurnal (one cycle per day) or semidiurnal (two cycles per day). For a definition of tidal constituents, see http://en.wikipedia.org/wiki/theory_of_tides. The majority of tide databases provide elevation amplitudes and phases for the eight primary harmonic constituents (M_2 , S_2 , K_2 , N_2 , K_1 , O_1 , P_1 , Q_1) that are astronomical tides and two steady-state overtones (M_4 and M_6). Most nonlinear overtones and compound tides tend to be significant only in shallow waters such as an embayment or estuary. Tidal databases do not include information about density effects, riverine driven circulation, wind and atmospheric pressure driven events and/or oceanic currents in nature.

The popular tidal databases are ADvanced CIRCulation (ADCIRC), TOPEX/POSEIDON global inverse solution (TPXO 2013), Le Provost (1995, 1998), and NWS (Figure 1). A brief description of each tidal database is provided, and users are encouraged to refer to the website of each database for detailed and specific information about the data sources.

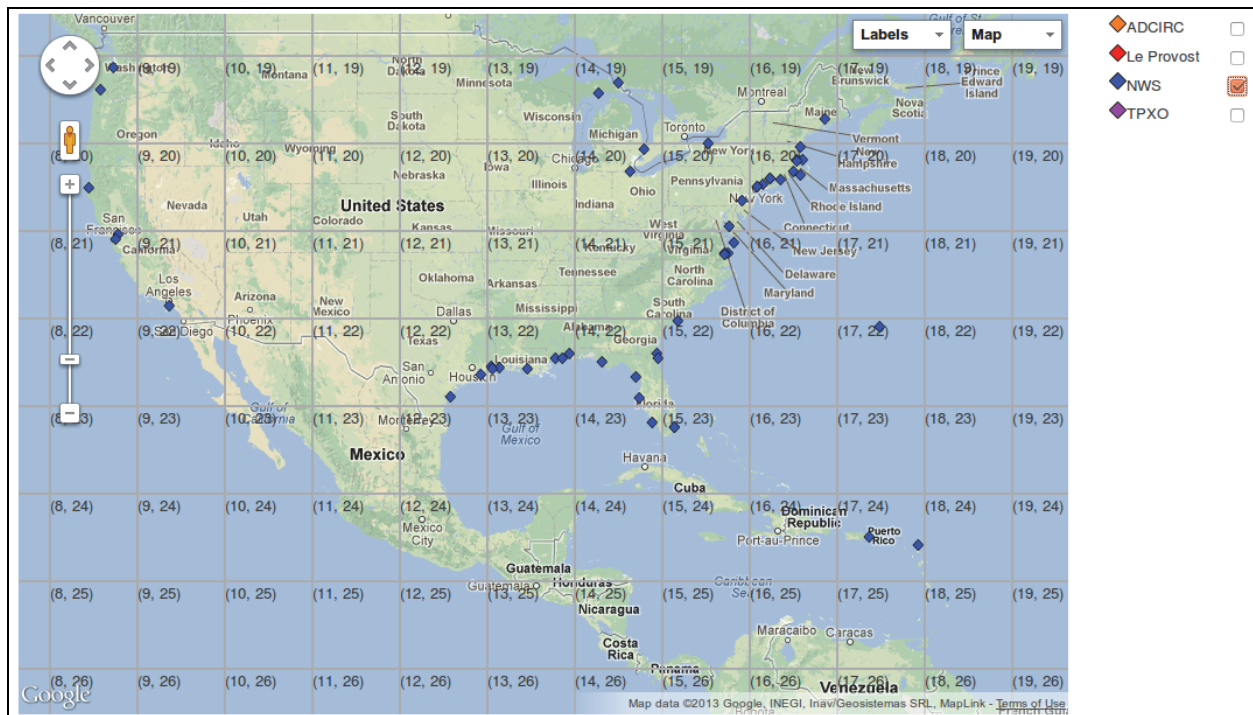


Figure 1. TideNet map of US coast.

The ADCIRC tidal database was developed using the ADvanced CIRCulation model, ADCIRC (Luettich et al. 1992), for the US coastal waters (Westerink et al. 1993). It contains tidal elevation and velocity constituents for currents in open waters within the US continental shelf. The ADCIRC computational domains were used for the Atlantic Ocean, the East Coast and Caribbean Sea, the Gulf of Mexico, and the Pacific Ocean, including Alaska and Hawaii (Mukai et al. 2001 and 2002; Spargo et al. 2004). This database defines the computed elevation and velocity amplitude and phase for the O_1 , K_1 , Q_1 , M_2 , S_2 , N_2 , and K_2 astronomical tidal constituents as well as the steady overtones M_4 and M_6 .

The TPXO is a global hydrodynamic ocean tidal database developed by Oregon State University. It is generated numerically from the best-fit by assimilating a Poseidon/Topex/Jason satellite altimeter-derived data set since 2002. The tides are provided as complex amplitudes of earth-relative sea-surface elevation for eight primary (M_2 , S_2 , N_2 , K_2 , K_1 , O_1 , P_1 , Q_1), two long period (M_f , M_m) and three non-linear (M_4 , MS_4 , MN_4) harmonic constituents, on a 1440×721 full global domain grid with a 0.25 degree resolution (TPXO 2013).

The Le Provost database has been available for a few decades, and its previous estimates of tides were revised in 1995 by assimilating a satellite altimeter-derived data set. This helped to improve accuracy of predictions using corrections to major constituents by TOPEX/POSEIDON data assimilation and also increase the number of constituents included in the numerical model used to develop predictions. The Le Provost database has been used in the generation of other more recent databases, including ADCIRC and TPXO.

The NWS is part of the National Oceanic and Atmospheric Administration (NOAA) databases, and it consists of both measured and predicted tidal information (NOAA 2013). The data from tide gauges are used to calibrate and validate numerical model predictions that provide tidal prediction parameters in the nearshore environment (NOAA 2013).

The following example illustrates the use of TideNet with the NWS database for a hypothetical Pacific Coast project. The illustration is done in a step-by-step manner, with commentaries and instructions to guide the users. In this example, TideNet Toolbox is used to identify water level, current, and wind data for a project needs. The illustration uses the water level and wind input needed for CMS-Wave (Lin et al. 2011a; Lin et al. 2011b; Lin et al. 2008) numerical modeling purposes.

EXAMPLE: TIDE DATA FOR A PACIFIC COAST PROJECT

The required information as input forcing for this project includes water levels and winds for the entire year of 2012. The water level and wind data are available as monthly mean or time series for the entire year. This application calls for saving the water level and wind speed data in an *.eng file for 1 November through 30 December 2012, at 6-hr intervals. We demonstrate in this example how to use TideNet to access the NWS database, fetch tidal data from the source, and prepare and store the required data in a file for project documents and for use in a numerical model.

Step 1. Select the sub-region of interest. To start TideNet, click the following link (<http://140.194.110.95/GoogleMap3/default/TideNet/>) on a CorpsNet machine. . The home page of the TideNet map displays available data sources. The four databases are ADCIRC, Le Provost, NWS, and TPXO (Figure 1). Use the mouse to click and zoom into the region of interest where water levels and wind data are desired (Figure 1).

Step 2. Select the type of data available from the TideNet database. In this example, Select NWS as the data source (Figure 1).

Step 3. Select the NWS station in the area of interest. A NWS station can be selected by clicking on one of the blue diamond icons. For this example, select NWS station 9414750 identified in Figure 2. Clicking on “View Station Home” will open a new browser window linking

to that station on NOAA's Tides and Currents webpage. The "Access Station 9414750 Data" option links TideNet to the NWS database to list the available data within TideNet. Figure 2 shows the available data (observed water level, wind speed and direction, and tidal constituents) at NWS 9414750.

Station 9414750

Starttime: 2012-11-01 00:00:00

Endtime: 2012-12-01 00:00:00

Datainterval: VerifiedHourlyHeight

Datum: MLLW

Relativetime: ☐

Outputtimeintervals: 1hr

Outputtimeformat: YYYY, MM, DD, HH, MM

Outputformat: CSV

Observedwaterlevel: ☒

Wind Speed and Direction: ☒

Tidal Constituents: ☐

Submit

December, 2012							
Today							
wk	Sun	Mon	Tue	Wed	Thu	Fri	Sat
47							1
48	2	3	4	5	6	7	8
49	9	10	11	12	13	14	15
50	16	17	18	19	20	21	22
51	23	24	25	26	27	28	29
52	30	31					

Time: 00 : 00

Select date

Figure 2. NWS station data download dialog.

Step 4. Set the time range to determine availability of data for project needs. Users can access available data at Station 9414750 by specifying a time window of interest and clicking “Submit” (Figure 2). Two options are available to change dates to select the desired timeframe. The first option is by manually typing in the “Start time” and “End time” boxes. The second option is to utilize the calendar. Note that a long time window may require a longer download time to obtain the data from the source. Data obtained for the specified time window are displayed in a new data display window (Figure 3). A “slide bar” is provided at the bottom of the data display window (Figure 3) for changing the start and end times. Users can drag this “slide bar” or draw a box on the display window to narrow the time window of interest. In this example, the time series data plot shows water level and wind speed, including the data gaps (if present). For a treatment of the data gaps, consult the methods discussed in Wilson et al. (2012).

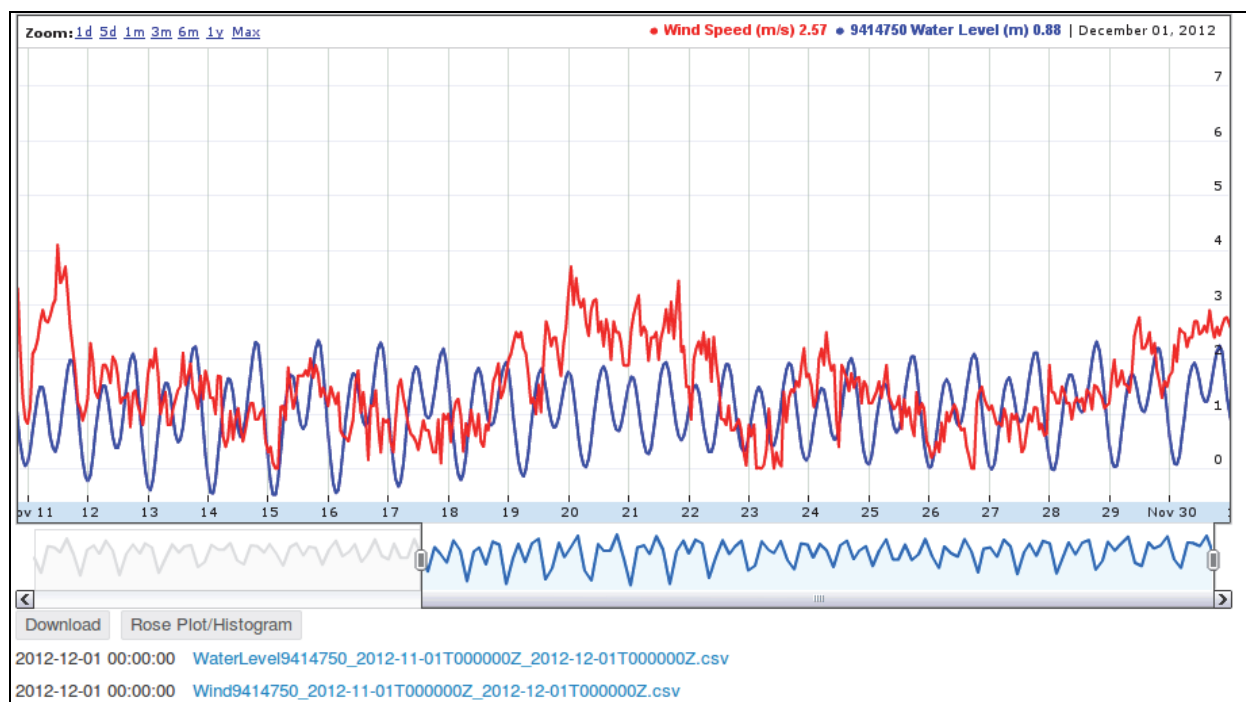


Figure 3. Plot of time series data range for NWS Station 9414750.

TideNet plots the tide and wind data using its tools. Figure 3 shows the time series of water level and wind speed at the NWS station 9414750 for 10 Nov 2012 through 1 Dec 2012.

Step 5. Perform additional analyses of data. To save data from the NWS data source for the specified time range (in this example, for Station 9414750), click on the “Download” button (Figure 3). The data are saved in *WaterLevel9414750_2012-11-01T000000Z_2012-12-01T000000Z.csv* and *Wind9414750_2012-11-01T000000Z_2012-12-01T000000Z.csv*. The “.csv” is an ASCII spreadsheet with comma-separated values in text format, which can be opened with Excel or any text editor. Table 1 presents partially tabulated *.csv data.

Users can perform desktop analyses of data saved by TideNet. In the future, analysis tools will be built into TideNet to prepare input water level and wind input files for circulation models (CMS, ADCIRC, etc.) and other wave models (STWAVE, etc.). Presently, in addition to the *.csv files,

the histogram and wind rose analyses are also available. Users can generate histogram and wind rose plots by clicking on “Rose Plot/Histogram” in Figure 3. Figure 4 illustrates the wind rose and wind histogram for the selected one-month time period.

Table 1. Tabulated data downloaded for NWS Station 9414750.									
	Year	Month	Day	Hour	Minute	Sec	WaterLevel(m)	Wind(m/s)	WindDir(deg)
1	2012	11	1	0	0	0	0.67	3.55	159.1
2	2012	11	1	1	0	0	0.3	3.28	156
3	2012	11	1	2	0	0	0.07	2.63	164.6
4	2012	11	1	3	0	0	0	2.2	142
5	2012	11	1	4	0	0	0.07	2.5	141
6	2012	11	1	5	0	0	0.36	2.6	144
7	2012	11	1	6	0	0	0.73	2.79	141.4
8	2012	11	1	7	0	0	1.12	2.54	134.8
9	2012	11	1	8	0	0	1.4	2.95	143.4
10	2012	11	1	9	0	0	1.61	2.19	173.1
11	2012	11	1	10	0	0	1.68	2.6	211
12	2012	11	1	11	0	0	1.55	2.1	216
13	2012	11	1	12	0	0	1.3	2.4	219
14	2012	11	1	13	0	0	1.05	2.8	205
15	2012	11	1	14	0	0	0.88	2.7	210.1
16	2012	11	1	15	0	0	0.86	2.08	192.1
17	2012	11	1	16	0	0	0.98	1.12	211
18	2012	11	1	17	0	0	1.24	0.4	253
19	2012	11	1	18	0	0	1.54	1.3	220
20	2012	11	1	19	0	0	1.79	1.5	192
21	2012	11	1	20	0	0	1.96	1.32	181.2
22	2012	11	1	21	0	0	1.96	2.5	183
23	2012	11	1	22	0	0	1.75	5.4	191
24	2012	11	1	23	0	0	1.34	5.95	199.9

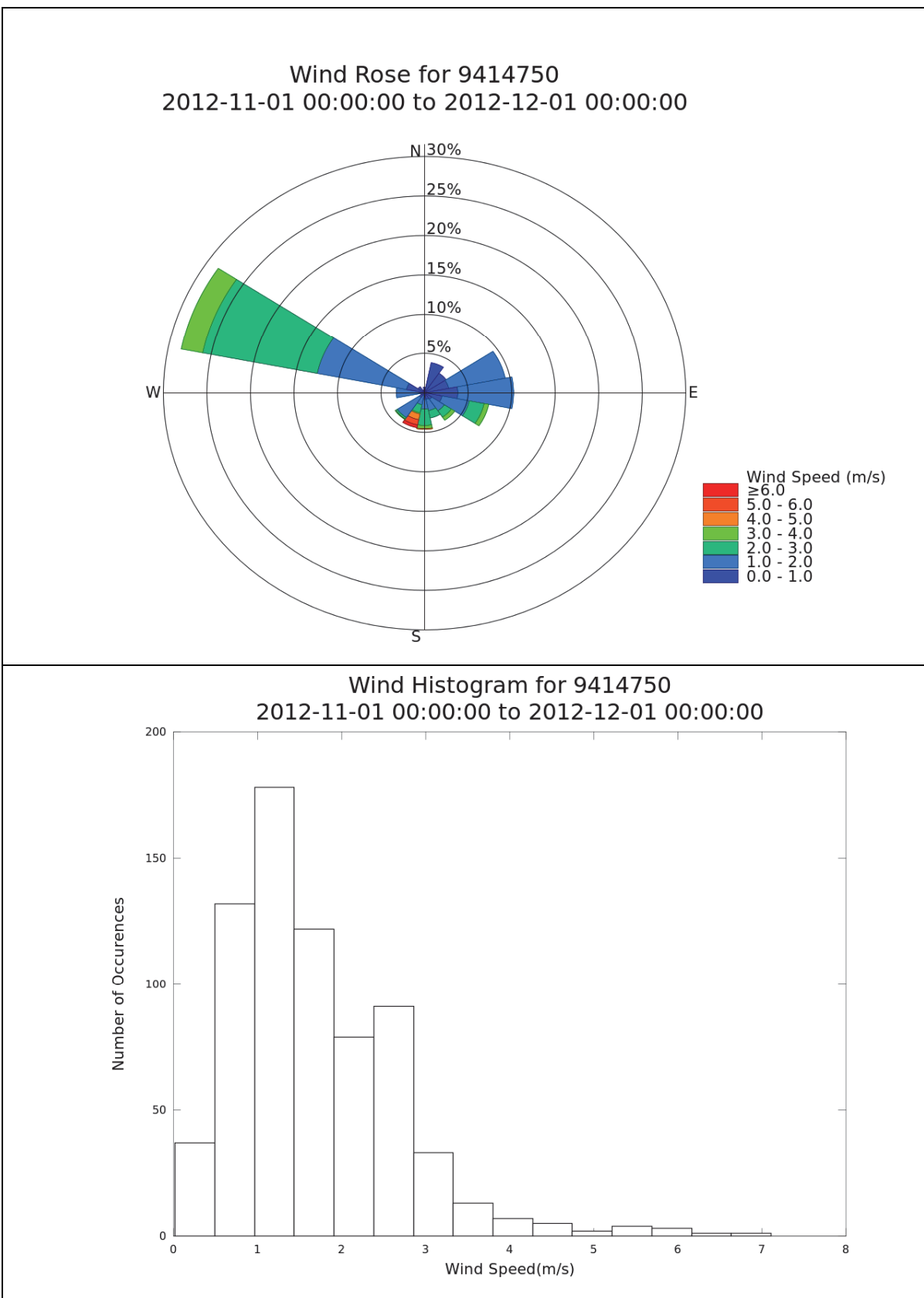


Figure 4. Wind rose and wind histogram for NWS 9414750.

CONCLUSIONS: This CHETN describes the application of TideNet to the NWS tidal database. An example is provided with a step-by-step procedure that demonstrates how to use TideNet to access the NWS wind and water level data from the NWS Web-based data source. The steps illustrate how to extract and analyze the NWS database for application to USACE coastal navigation and storm damage reduction projects. This CHETN serves as a user-guide for planners and engineers to obtain tidal data for numerical modeling, project planning, and design and evaluation study reports. The NWS data source may have data gaps and vary in content, complexity, and accuracy of information. These data may require additional processing for use in USACE studies. TideNet tools will allow users to identify data gaps and provide options for handling data gaps. The present analysis capabilities include data analysis methods to generate histogram and wind rose data for project needs. TideNet can be used by Districts for project-specific data available from the NWS or some other data sources that will be added to TideNet system in the future. User feedback is welcome for expanding TideNet capabilities to address the needs of the USACE community. We ask users to report problems and inform us about additional needs for different engineering applications.

POINTS OF CONTACT: This CHETN was prepared as part of the Coastal Inlets Research Program (CIRP) and was written by a team. The POC for technical inquiries is Dr. Zeki Demirebilek (Zeki.Demirebilek@usace.army.mil). For information about CIRP, please contact the CIRP Program Manager, Dr. Julie Dean Rosati (tel: 251-694-3719) or by email (Julie.D.Rosati@usace.army.mil). This technical note should be referenced as follows:

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REFERENCES

- Demirebilek, Z., L. Lin, D. Wilson, and J. Rosati. 2013. *Wavenet: A web-based metocean data access, processing and analysis tool, part 2 -- WIS database*. ERDC/CHL CHETN-IV-92 Vicksburg, MS: US Army Engineer Research and Development Center.
- Hendershott, M. C. 1981. Long waves and ocean tides, Evolution of physical oceanography. Ed. B. A. Warren and C. Wunsch, 292-341. Cambridge, MA: MIT Press.
- Lin, L., Z. Demirebilek, H. Mase, J. Zheng, and F. Yamada. 2008. *CMS-Wave: A nearshore spectral wave processes model for coastal inlets and navigation projects*. ERDC/CHL TR-08-13. Vicksburg, MS: US Army Engineer Research and Development Center.
- Lin, L., Z. Demirebilek, R. Thomas, and J. Rosati. 2011a. *Verification and validation of coastal modeling system, report 2: CMS-Wave*. ERDC/CHL TR-11-10. Vicksburg, MS: US Army Engineer Research and Development Center.
- Lin, L., Z. Demirebilek, and H. Mase. 2011b. Recent capabilities of CMS-Wave: A coastal wave model for inlets and navigation projects. *Journal of Coastal Research*, Special Issue 59:7-14.
- Le Provost, C., A. F. Bennett, and D. E. Cartwright. 1995. Ocean tides for and from TOPEX/POSEIDON. *Science* 267:639-642.
- Le Provost, C., F. Lyard, J. M. Molines, M. L. Genco, and F. Rabilloud. 1998. A hydrodynamic ocean tide model improved by assimilating a satellite altimeter-derived data set. *Journal of Geophysical Research* 103:5513-5529.

- Luetlich, R. A., J. J. Westerink, and N. W. Scheffner. 1992. *ADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries, Report 1: Theory and methodology of ADCIRC-2DDI and ADCIRC-3DL*. Tech. Report DRP-92-6. Vicksburg, MS: US Army Engineer Waterways Experiment Station.
- Mukai, A.Y., J. J. Westerink, and R. A. Luetlich. 2001. *Guidelines for using Eastcoast 2001 database of tidal constituents within Western North Atlantic Ocean, Gulf of Mexico and Caribbean Sea*. CHETN-IV-40. Vicksburg, MS: US Army Engineer Research and Development Center..
- Mukai, A.Y., J. J. Westerink, and R. A. Luetlich. 2002. *Eastcoast 2001, a tidal constituent database for western north Atlantic Ocean, Gulf of Mexico and Caribbean*. ERDC/CHL TR-02-24. Vicksburg, MS: US Army Engineer Research and Development Center.. <http://acwc.sdp.sirsi.net/client/search/asset/1000698>
- National Oceanic and Atmospheric Administration (NOAA). 2013. Tides & Currents. <http://tidesandcurrents.noaa.gov/>
- Spargo, E. A., J. J. Westerink, R. A. Luetlich, and D. J. Mark. 2004. *ENPAC 2003, a tidal constituent database for eastern north Pacific Ocean*. ERDC/CHL TR-04-12. Vicksburg, MS: US Army Engineer Research and Development Center. <http://acwc.sdp.sirsi.net/client/search/asset/1000739>
- TOPEX/Poseidon Global Inverse Solution (TPXO). 2013. The OSU global tide database: TOPEX/Poseidon Global Inverse Solution TPXO. <http://volkov.oce.orst.edu/tides/global.html>
- Westerink, J. J., R. A. Luetlich, and N. W. Scheffner. 1993. *ADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries, Report 3: Development of a tidal constituent database for the western north Atlantic and Gulf of Mexico*. Tech. Report DRP 92-6. Vicksburg, MS: US Army Engineer Waterways Experiment Station.
- Wilson, D., J. Rosati, Z. Demirebilek, and L. Lin. 2012. *Wavenet: A web based metocean data access, processing and analysis tool*. ERDC/CHL CHETN-IV-83. Vicksburg, MS: US Army Engineer Research and Development Center.

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